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JC586 U.S. PTO
09/14/99

Our Case No. 9281-3411
Client Reference No. J US98083

PATENT APPLICATION TRANSMITTAL LETTER

jc503 U.S. PTO
09/395666
09/14/99

To the Assistant Commissioner for Patents:

Transmitted herewith for filing is the patent application of Takahito Mafune.

for REFLECTION LIQUID CRYSTAL DISPLAY CAPABLE OF DISPLAYING PICTURES IN IMPROVED COLOR PURITY.

Enclosed are:

- ☒ 13 pages of application (including title page), 2 sheet(s) of drawings and the following Appendices : n/a.
- ☒ Preliminary Amendment
- ☒ Declaration and Power of Attorney for Patent Application
- ☒ Assignment transmittal letter and Assignment of the invention to : Alps Electric Co., Ltd.
- ☒ Submission of Certified Copy of Priority Document(s) and certified copy of Japanese Application No(s). 10-260650
- ☐ Information Disclosure Statement, Form PTO-1449 and Reference(s)

Claims as Filed	Col. 1	Col. 2	Small Entity			Other Than Small Entity	
For	No. Filed	No. Extra	Rate	Fee	or	Rate	Fee
Basic Fee				$ 380	or		$ 760
Total Claims	2-20	0	x$9=	$	or	x$18=	$
Indep. Claims	1-3	0	x$39=	$	or	x$78=	$
Multiple Dependent Claims Present			+$130=	$	or	+$260=	$
*If the difference in col. 1 is less than zero, enter "0" in col. 2.			Total	$	or	Total	$760

- ☐ Please charge my Deposit Account No. 23-1925 in the amount of $_____. A duplicate copy of this sheet is enclosed.
- ☒ A check in the amount of $760.00 to cover the filing fee is enclosed.
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  - ☐ Any filing fees under 37 CFR § 1.16 for presentation of extra claims.
  - ☐ Any patent application processing fees under 37 CFR § 1.17.
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9/14/99
Date

Gustavo Siller, Jr.
BRINKS HOFER GILSON & LIONE
Registration No. 32,305

09395666 090499

"Express Mail" mailing label number EL 448 309 344 US

Date of Deposit: 9/14/99

Our Case No. 9281-3411
Client Ref. No. J US98083

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Takahito Mafune

Serial No.: To Be Assigned

Filing Date: Herewith

For: REFLECTION LIQUID CRYSTAL DISPLAY CAPABLE OF DISPLAYING PICTURES IN IMPROVED COLOR PURITY

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Prior to examination of the above-identified application, please amend the application as follows:

In the Specification

On page 1, line 8 delete "in an" and substitute --having--;

On page 1, line 17 delete "travel" and substitute --travels--;

On page 2, line 17 after "disadvantages" delete ",";

On page 4, line 1 delete "lonely" and substitute --only--;

Respectfully submitted,

Gustavo Siller, Jr.
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Attorney for Applicant

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Our Case No. 9281-3411
Client Reference No. J US98083

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
APPLICATION FOR UNITED STATES LETTERS PATENT

INVENTOR: Takahito Mafune

TITLE: REFLECTION LIQUID CRYSTAL DISPLAY CAPABLE OF DISPLAYING PICTURES IN IMPROVED COLOR PURITY

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SPECIFICATION

REFLECTION LIQUID CRYSTAL DISPLAY CAPABLE OF DISPLAYING PICTURES IN IMPROVED COLOR PURITY

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a reflection liquid crystal display and, more particularly, to a reflection liquid crystal display capable of displaying pictures in an improved color purity.

Description of the Related Art

There is a known color liquid crystal display of an electric field-controlled birefringence system (hereinafter referred to as "ECB system").

In an STN liquid crystal display, a liquid crystal layer has a birefringent effect to split a light beam. Therefore, when white light linearly polarized by a back polarizing plate travel through the liquid crystal layer, there occurs wavelength dispersion causing the combination of elliptically polarized light beams having major axes of different directions depending on wavelength. Therefore, different transmittance curves for light beams of different wavelengths, such as red, green and blue light beams, are obtained when voltage applied across the liquid crystal layer is varied gradually to change Δnd which is a product of Δn and d (Δn is the index anisotropy of the liquid crystal layer and d is the thickness of the liquid

crystal layer).

When the product Δnd in a state where any voltage is not applied across the liquid crystal layer is not greater than a predetermined value and a birefringent layer having Δnd substantially equal to that of the liquid crystal layer is interposed between a liquid crystal cell and a front polarizing plate, the birefringent effect of the liquid crystal layer in a state where any voltage is not applied across the liquid crystal layer can substantially completely be cancelled out and light of characteristics nearly equal to those of the incident white light can be emitted. Therefore, pictures can be displayed in different colors, such as red, green and blue, by continuously varying the Δnd of the liquid crystal layer by controlling the voltage applied across the liquid crystal layer. Thus, color change can be achieved by voltage control.

The ECB system does not employ any color filter having disadvantages, such as high manufacturing cost and low transmittance. Therefore, the liquid crystal display of the ECB system displays pictures on a bright screen, does not consume much power and can be manufactured at a low manufacturing cost. The ECB system can be applied to both transmission liquid crystal displays and reflection liquid crystal displays.

Referring to Fig. 3, a reflection liquid crystal display 51 of the ECB system has a liquid crystal layer 52, an upper glass substrate 53 and a lower glass substrate 54. An upper transparent electrode layer 55 and an upper alignment layer

56 are formed in that order on the inner surface of the upper glass substrate 53. A lower transparent electrode layer 57 and a lower alignment layer 58 are formed in that order on the inner surface of the lower glass substrate 54.

The liquid crystal layer 52 is sandwiched between the upper alignment layer 56 and the lower alignment layer 58. A phase plate 59 capable of functioning as a birefringent layer, and an upper polarizing plate 60 are placed in that order on the outer surface of the upper glass substrate 53. A lower polarizing plate 61 and a reflecting plate 62 are placed in that order on the outer surface of the lower glass substrate 54. The reflecting plate 62 is formed by coating an irregular surface of a polyester film 65 with a metal reflecting film 63 of aluminum or silver by evaporation or the like. The metal reflecting film 63 has an irregular surface 64. The reflecting plate 62 is placed on the lower polarizing plate 61 with the irregular surface 64 of the metal reflecting film 63 in contact with the lower polarizing plate 61.

The reflection liquid crystal display displays pictures by using only sunlight or illuminating light and does not use any backlight. Although the reflection liquid crystal display has the advantage of operating at low power consumption, the lightness of pictures displayed by the reflection liquid crystal display is somewhat lower than that of pictures displayed by the transmission liquid crystal display provided with a backlight.

The liquid crystal display of the ECB system displays

colors lonely by controlling the voltage applied across the liquid crystal layer without using any color filters. However, the liquid crystal display of the ECB system has difficulty in clearly displaying red and green in a satisfactory color purity.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a reflection liquid crystal display of the ECB system capable of displaying pictures in improved lightness and of displaying particularly red and green in improved color purity.

According to one aspect of the present invention, a reflection liquid crystal display comprises a first transparent substrate, a second transparent substrate disposed opposite to the first transparent substrate, and a liquid crystal layer sandwiched between the first and the second transparent substrate; wherein a transparent electrode layer and an alignment layer are formed in that order on the inner surface of the first transparent substrate, a reflecting polarizing film formed by laminating a transparent scattering layer and a light absorbing layer is placed on the outer surface of the first transparent substrate, a transparent electrode layer and an alignment layer are formed in that order on the inner surface of the second transparent substrate, and a phase plate and a polarizing plate are placed in that order on the outer surface of the second transparent substrate.

The reflection liquid crystal display in accordance with

the present invention is provided with the reflection polarizing film instead of the polarizing plate and the reflecting plate to improve the color purity of red and green.

Preferably, the liquid crystal layer of the reflection liquid crystal display has a helical structure twisted through an angle in the range of 240° to 260°, a value $\Delta n_1 d_1$ which is a product of Δn_1 and d_1, where Δn_1 is the index anisotropy of the phase plate and d_1 is the thickness of the phase plate, is in the range of 1000 to 2000 nm, a value Δnd which is a product of Δn and d, where Δn is the index anisotropy of the liquid crystal and d is the thickness of the liquid crystal layer, is in the range of 800 to 1800 nm, the absorption axis of the polarizing plate is inclined to the delay axis of the phase plate at an angle in the range of -40° to -60° in a counterclockwise direction as viewed from the side of incident light, the delay axis of the phase plate is inclined to the alignment direction of the second alignment layer on the second transparent substrate at an angle in the range of -65° to -85° in a counterclockwise direction as viewed from the side of incident light, the absorption axis of the reflecting polarizing film is inclined to the alignment direction of the first alignment layer of the first transparent substrate at an angle in the range of +35° to +55° in a counterclockwise direction as viewed from the side of incident light.

Only a certain measure of improvement can be expected when the reflection liquid crystal display of the present invention is provided with only the reflecting polarizing film.

Further effect can be expected when the polarizing plate, the phase plate and a rubbing axis are arranged in an optimum axis arrangement. The inventors of the present invention found through studies of axis arrangement that the foregoing axis arrangement further enhances the lightness color clearness of pictures displayed on the reflection liquid crystal display.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a fragmentary typical sectional view of a reflection liquid crystal display in a preferred embodiment according to the present invention;

Fig. 2 is a typical view of assistance in explaining the arrangement of axes in the reflection liquid crystal display shown in Fig. 1; and

Fig. 3 is a fragmentary typical sectional view of a conventional reflection liquid crystal display of the ECB system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1, a reflection liquid crystal display 1 in a preferred embodiment according to the present invention has an upper glass substrate 3, a lower glass substrate 4 disposed opposite to the upper glass substrate 3, and a liquid

crystal layer 2 sandwiched between the upper glass substrate 3 and the lower glass substrate 4. An upper transparent electrode layer 5 and an upper alignment layer 6 are formed in that order on the inner surface of the first transparent substrate 3. A lower transparent electrode layer 7 and a lower alignment layer 8 are formed in that order on the inner surface of the lower glass substrate 4. The liquid crystal layer 2 is sandwiched between the upper alignment layer 6 and the lower alignment layer 8. A phase plate 9 and an upper polarizing plate 10 are placed on the outer surface of the upper glass substrate 3. A reflecting polarizing film 13 formed by laminating a transparent scattering layer 11 and a light absorbing layer 12 is placed on the outer surface of the lower glass substrate 4.

The reflecting polarizing film 13 is, for example, a reflecting polarizing film RDF-B commercially available from Sumitomo 3M. The reflecting polarizing film RDF-B has a layer of a polyester resin as the transparent scattering layer 11, and a black layer of an acrylic resin as the light absorbing layer 12. The light absorbing layer 12 is coated with a protective film of a polyolefin resin. A diffusive adhesive layer of an acrylic adhesive and a separating PET film are laminated in that order on the transparent scattering layer 11.

When using the reflecting polarizing film RDF-B, the PET film is peeled off and the diffusive adhesive layer is applied to the lower glass substrate 4. The relative reflection

luminance of the reflecting liquid crystal display of the present invention employing the reflecting polarizing film RDF-B is higher than that of a reflecting liquid crystal display employing a polarizing plate and a reflecting plate by about 20%. The reflecting liquid crystal display of the present invention is able to display pictures of high picture quality not giving rough appearance and parallax. The reflection liquid crystal display has a wide angle of view and can be formed in a thin structure.

The use of the reflecting polarizing film 13 instead of the polarizing plate and the reflecting plate improves the color purity of red and green images.

An optimum conditions for axis arrangement for the reflection liquid crystal display of the present invention will be described hereinafter. Fig. 2 shows an axis arrangement in the reflection liquid crystal display shown in Fig. 1, in which the liquid crystal layer 2 has a helical structure twisted through 240° in the direction of the thickness thereof. The angle at which the rubbing axis of the upper alignment layer 6 formed on the upper glass substrate 3 extend to the rubbing axis of the lower alignment layer 8 formed on the lower glass substrate 4 is 240° in a counterclockwise direction as viewed from the side of incident light. The product Δnd of the index anisotropy Δn of the liquid crystal and the thickness d of the liquid crystal layer 2 is in the range of 800 to 1800 nm.

The product $\Delta n_1 d_1$ of the index anisotropy Δn_1 of the phase plate 9 and the thickness d_1 of the phase plate 9 is in the

range of 1000 to 2000 nm. The delay axis of the phase plate 9 is inclined at -75° in a counterclockwise direction as viewed from the side of incident light to the rubbing axis of the upper alignment layer 6. The absorption axis of the polarizing plate 10 is inclined at -50° in a counterclockwise direction as viewed from the side of incident light to the delay axis. The absorption axis of the reflecting polarizing film 13 is inclined at +45° in a counterclockwise direction as viewed from the side of incident light to the rubbing axis of the lower alignment layer 8 formed on the lower glass substrate 4. Since the components of the reflection liquid crystal display are disposed in the foregoing axis arrangement, lightness of pictures is enhanced and colors are displayed clearly.

The values of the product Δnd and the product $\Delta n_1 d_1$, the axis arrangement of the polarizing plate, the phase plate and the alignment layers may be other than those mentioned above and may be changed within the scope of the present invention.

Although the invention has been described in its preferred embodiment with a certain degree of particularity, obviously many changes and variations are possible therein. It is therefore to be understood that the present invention may be practiced otherwise than as specifically described herein without departing from the scope and spirit thereof.

What is claimed is:

1. A reflection liquid crystal display comprising:

a first transparent substrate;

a second transparent substrate disposed opposite to the first transparent substrate;

a liquid crystal layer sandwiched between the first and the second transparent substrate;

a first transparent electrode layer formed on an inner surface of the first transparent substrate;

a first alignment layer formed on the first transparent electrode layer;

a reflecting polarizing film formed by laminating a transparent scattering layer and a light absorbing layer, and placed on an outer surface of the first transparent substrate;

a second transparent electrode layer formed on an inner surface of the second transparent substrate;

a second alignment layer formed on the second transparent electrode layer;

a phase plate placed on an outer surface of the second transparent substrate; and

a polarizing plate placed on the second transparent substrate.

2. The reflection liquid crystal display according to claim 1, wherein the liquid crystal layer has a helical structure twisted through an angle in the range of 240° to 260°, a value $\Delta n_1 d_1$ which is a product of Δn_1 and d_1, where Δn_1 is the index anisotropy of the phase plate and d_1 is the thickness

of the phase plate, is in the range of 1000 to 2000 nm, a value Δnd which is a product of Δn and d, where Δn is the index anisotropy of the liquid crystal and d is the thickness of the liquid crystal layer, is in the range of 800 to 1800 nm, the absorption axis of the polarizing plate is inclined to the delay axis of the phase plate at an angle in the range of -40° to -60° in a counterclockwise direction as viewed from the side of incident light, the delay axis of the phase plate is inclined to the alignment direction of the second alignment layer on the second transparent substrate at an angle in the range of -65° to -85° in a counterclockwise direction as viewed from the side of incident light, the absorption axis of the reflecting polarizing film is inclined to the alignment direction of the first alignment layer of the first transparent substrate at an angle in the range of +35° to +55° in a counterclockwise direction as viewed from the side of incident light.

ABSTRACT

A reflection liquid crystal display comprises a first transparent substrate, a second transparent substrate disposed opposite to the first transparent substrate, and a liquid crystal layer sandwiched between the first and the second transparent substrate. A transparent electrode layer and an alignment layer are formed in that order on the inner surface of the first transparent substrate, a reflecting polarizing film formed by laminating a transparent scattering layer and a light absorbing layer is placed on the outer surface of the first transparent substrate, a transparent electrode layer and an alignment layer are formed in that order on the inner surface of the second transparent substrate, and a phase plate and a polarizing plate are placed in that order on the outer surface of the second transparent substrate.

FIG. 1

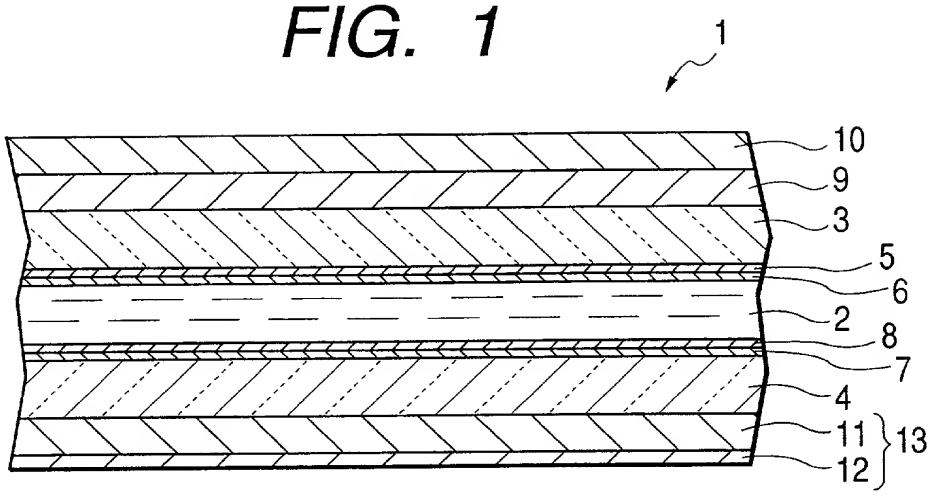
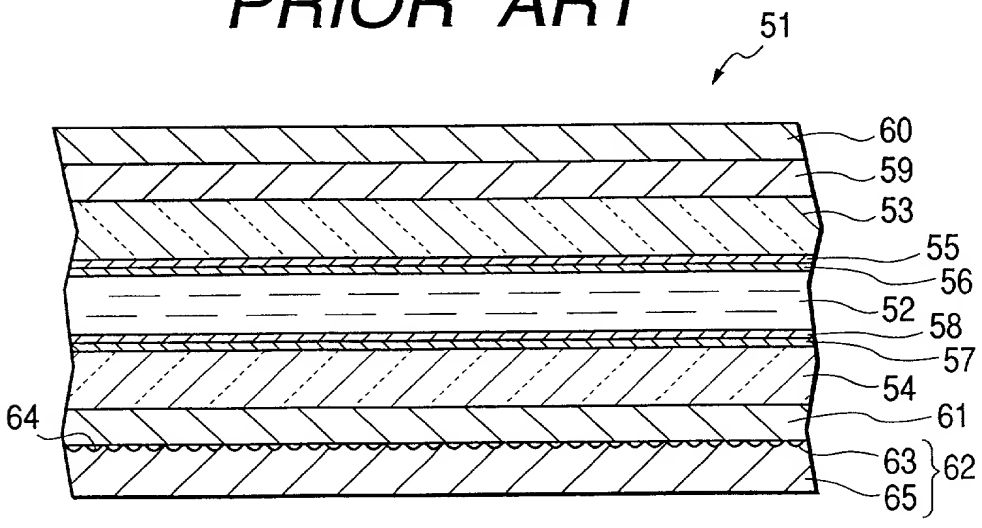


FIG. 3
PRIOR ART



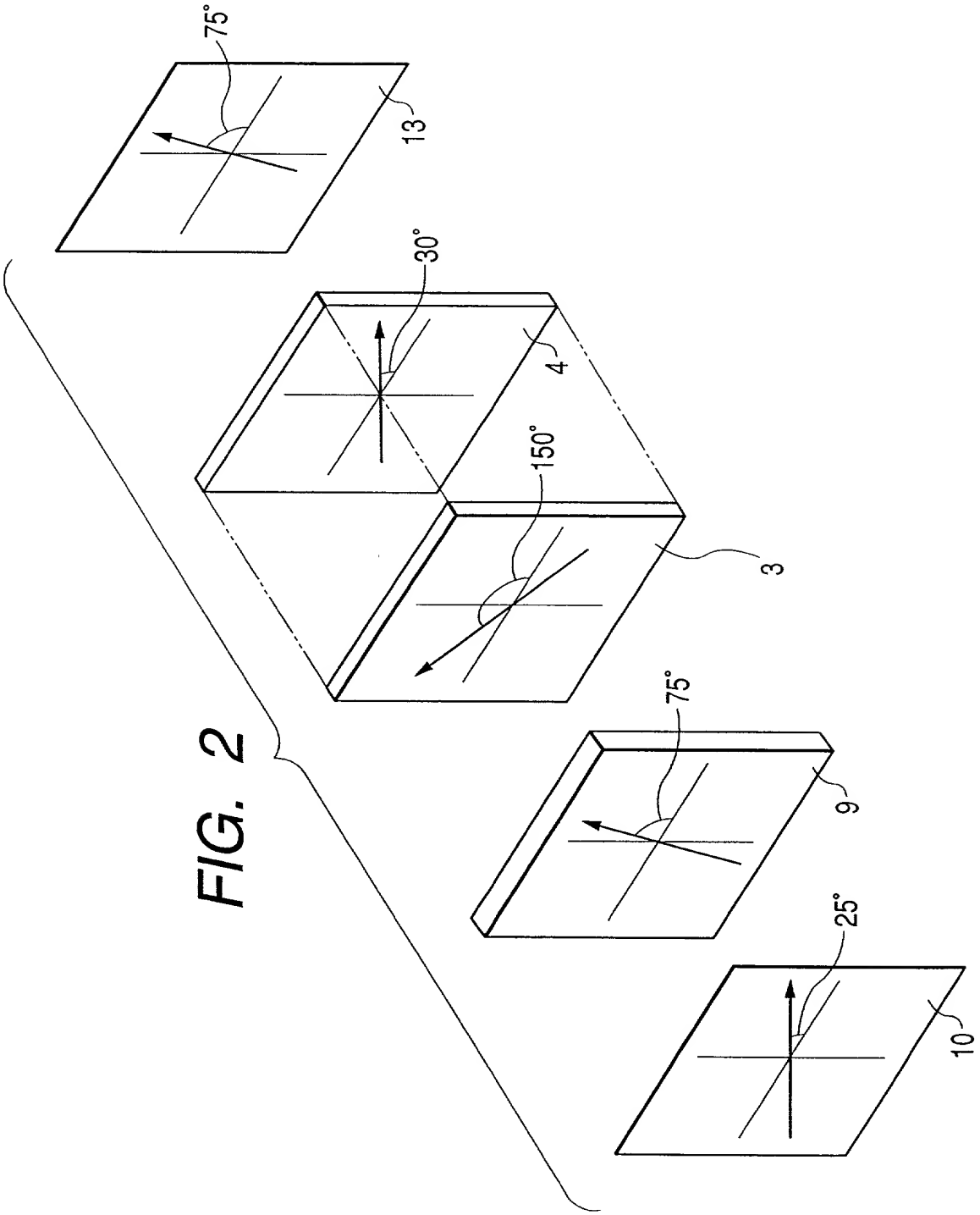


FIG. 2

PTO/SB/106 (8-96)
Approved for use through 9/30/98, OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Refrection Liquid Crystal Display Capable of Displaying Pictures in Improved Color Purity

上記発明の明細書（下記の欄でx印がついていない場合は、本書に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ __月__日に提出され、米国出願番号または特許協定条約国際出願番号を_____とし、
（該当する場合）_____ に訂正されました。

☐ was filed on _____
as United States Application Number or
PCT International Application Number
_____ and was amended on
_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第３７編第１条５６項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

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Japanese Language Declaration
(日本語宣言書)

私は、米国法典第３５編１１９条(a)-(d)項又は３６５条(b)項に基き下記の、米国以外の国の少なくとも一ヵ国を指定している特許協力条約３６５(a)項に基ずく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
10-260650	Japan	14/09/1998	☐
			☐

私は、第３５編米国法典１１９条(e)項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Application No.) (出願番号)	(Filing Date) (出願日)

私は、下記の米国法典第３５編１２０条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約３６５条(c)に基ずく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第３５編１１２条第１項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第３７編１条５６項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

私は、私自身の知識に基ずいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基ずく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第１８編第１００１条に基ずき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Japanese Language Declaration
(日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。（弁護士、または代理人の氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(list name and registration number)*

See Attachment A

書類送付先

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Direct Telephone Calls to: *(name and telephone number)*

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国籍	Citizenship Japan
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第二共同発明者	Full name of second joint inventor, if any
第二共同発明者 日付	Second inventor's signature Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address c/o ALPS ELECTRIC CO., LTD. 1-7 Yukigaya, Otsuka-cho, Ota-ku, Tokyo, Japan

（第三以降の共同発明者についても同様に記載し、署名をすること）

(Supply similar information and signature for third and subsequent joint inventors.)

ATTACHMENT A

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Steven G. Steger	40,185
Tadashi Horie	40,437
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Jason C. White	42,223